LANL Rides Wave of the Future
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LOS ALAMOS- Phil Jones' computer screen shows the Kuroshio Current slithering up Japan's east coast like a snake.

The colors- orange and yellow to signify warm water- are artificial. But the reality behind them marks a significant step for scientists trying to understand Earth's climate.

That is because this version of the Kuroshio Current- a dominant feature in the climate of the Far East- was created entirely by computer simulation.

A group of Los Alamos National Laboratory scientists plugged real ocean data into the computer, along with detailed equations about how things such as heat and salinity behave.

When they spin up the computer, out pops the Kuroshio Current and a host of other real-life features, like El NiÒo and the Gulf Stream, that are central to how Earth's oceans behave and critical to understanding the planet's climate.

While atmospheric models usually get the climate research glory as they tell their stories about the risks of global warming, ocean models are often relegated to anonymous roles in the supporting cast.

But as fears rise about the risks of rapid climate change triggered by shifts in ocean currents, the Los Alamos team and other ocean modelers are increasingly being given a lead role in climate debates.

You could think of Earth's climate as a giant heating and cooling system. Winds and ocean currents act like duct work carrying heat and cold around the planet.
Winds are the fickle carriers of weather, changing day to day as storms rise and fall, skittering across the planet's surface like mice across the kitchen floor.
The oceans, by comparison, are lumbering behemoths, changing slowly over periods of years to decades. But when they change, the effects on land where we live can be enormous.

Temperature changes in the equatorial Pacific- patterns named El NiÒo and La NiÒa- make the difference between a wet winter and a drought in New Mexico, for example.
More important for global climate change research, the Gulf Stream running up the East Coast of North America acts like a giant heating duct for Europe, carrying tropical warmth to a continent that would otherwise be an ice box.

Scientists think that, in the past, the Gulf Stream has shut down in a hurry, overhauling Europe's climate. So understanding what might happen to that current in the future is one of the critical problems in global climate change research.

It is an accident of history that scientists working on the high desert mesas of Los Alamos, 500 miles from the nearest ocean, are among the world's leading ocean modelers.
The effort dates to 1979, when a senior labor manager concluded that climate change was an important energy-related issue. Nuclear weapons have always been Los Alamos

National Laboratory's primary mission, but energy is part of the lab's research portfolio as well.

A young Bob Malone, then just starting his career at the lab, was dispatched to the National Center for Atmospheric Research in Boulder to learn about climate simulations.

The work followed a meandering route, including atmospheric simulations of "nuclear winter"- the effect of nuclear war on climate- before Malone and his colleagues settled in the early 1990s into ocean simulations.

At the time they started the ocean work, Malone said, the atmospheric research field was crowded and ocean modeling seemed like a scientific market opportunity.
Today, Malone heads up a team of 14 Los Alamos scientists working on the project, and the computer model they developed to simulate the ocean- the Parallel Ocean Program, known as POP- is used by scientists around the world in their ocean studies.

In addition to POP, team members have developed simulations of sea ice, which is another significant chapter of the climate story. They have also developed alternative ocean simulations as a way of testing their models of how the system functions.

To make the models, the scientists carve the ocean up into boxes one tenth of a degree of latitude on a side. For each box, the computer keeps track of things such as temperature, salinity and the water's movement, calculating and recalculating how those parameters change over time.

Add 40 layers of ocean depth, and the resulting computer simulation must keep track of a quarter of a billion boxes of ocean water.

When the modeling was done with larger, one-degree boxes, key small-scale detail was lost, things like eddies rolling off ocean currents, according to Malone. With one-tenth degree boxes, which Los Alamos moved to in the late 1990s, the simulation's resolution is now fine enough that its results seem to match the real-world ocean.

"It becomes more and more detailed and realistic in appearance," Malone explained.
This comes with a price, though. Reducing the size of the boxes by a factor of ten in each direction means a hundred times as many boxes. Because of changes in time steps used in the simulation, the result is a calculation that requires a thousand times as much computing power.

To understand ocean's effect on global climate, POP is then run together with a similar atmospheric climate model. Adding in the sea ice simulation gives scientists a way to dial up and down the knobs on Earth's future climate, estimating how much emissions of greenhouse gases from fuel burning might change our planet.

The simulations are important because, unlike most researchers, climate scientists have no way other than a simulation to try to determine how Earth's climate might change over the next century.

"You can't run an experiment on the real Earth," said Rainer Bleck, another member of the Los Alamos ocean team.